Exterior Insulation & Overclad Retrofits

Residential Energy Efficiency Stakeholder Meeting

March 2, 2012 – Austin, TX

Exterior Insulation

- Incredible practical experience:
  - New construction – nearly a century
  - Retrofit applications – many decades

1980s ON – a “weird” builder

1990s ON – a “good” builder

2000s ON – a “typical” builder

2000s ON – another “typical” builder

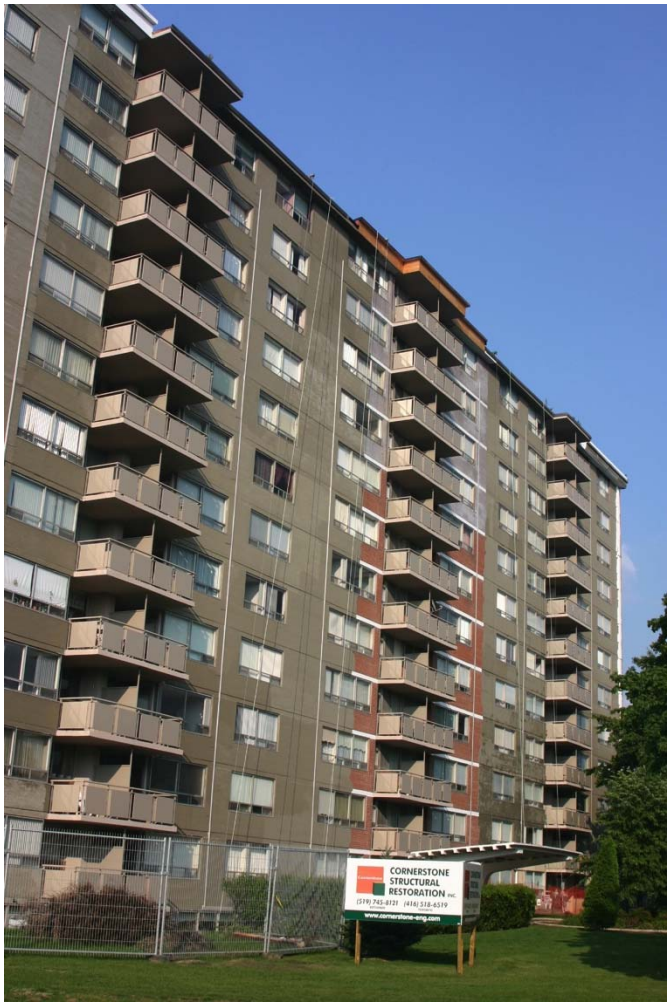
2000s MA – a “High-R” assembly

1990s – “modest” retrofit

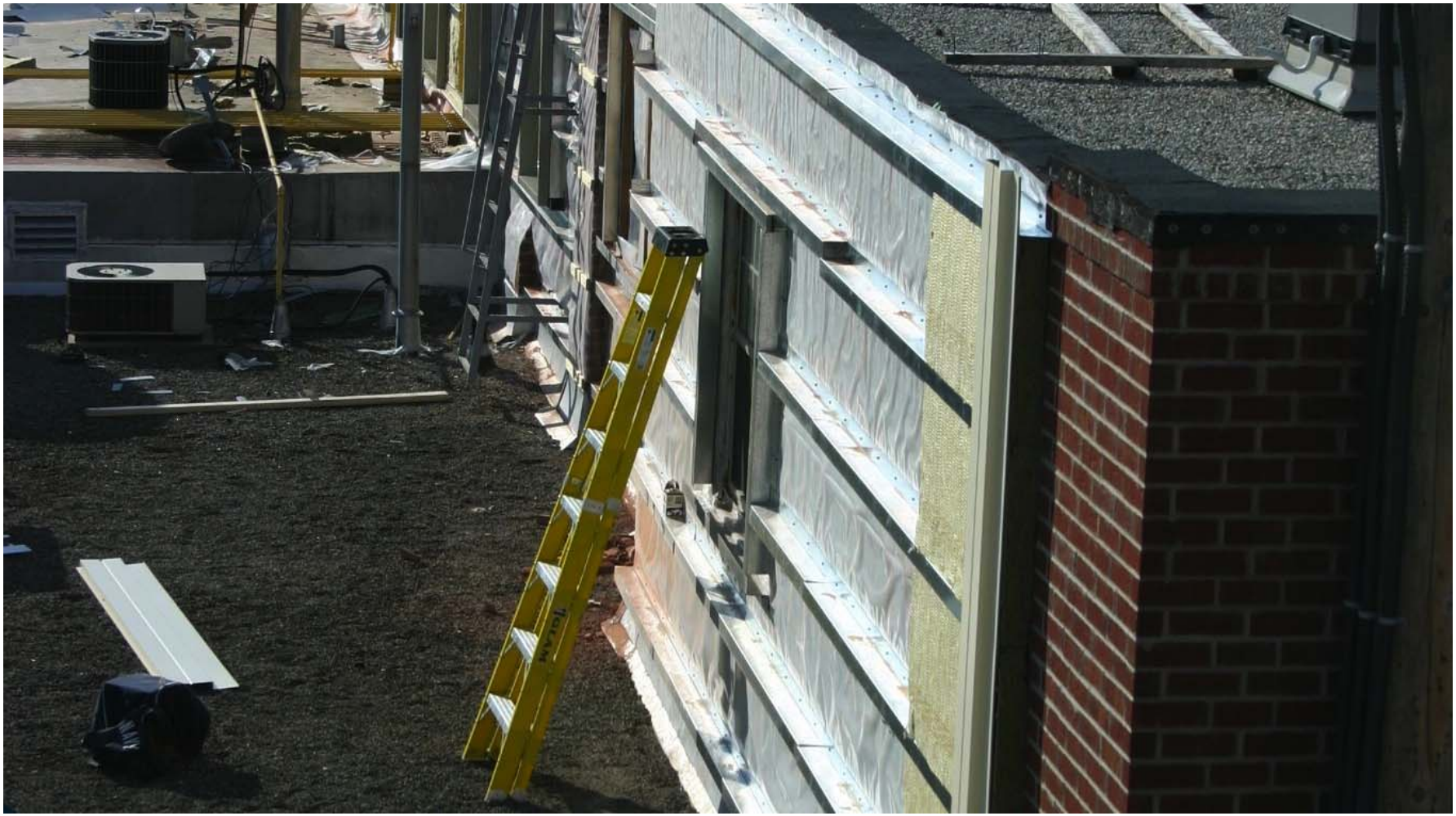
2000s – “High-R” retrofit

1980s – faced semi-rigid fiberglass

2000s – masonry “High-R” retrofit



2000s – masonry rockwool retrofit

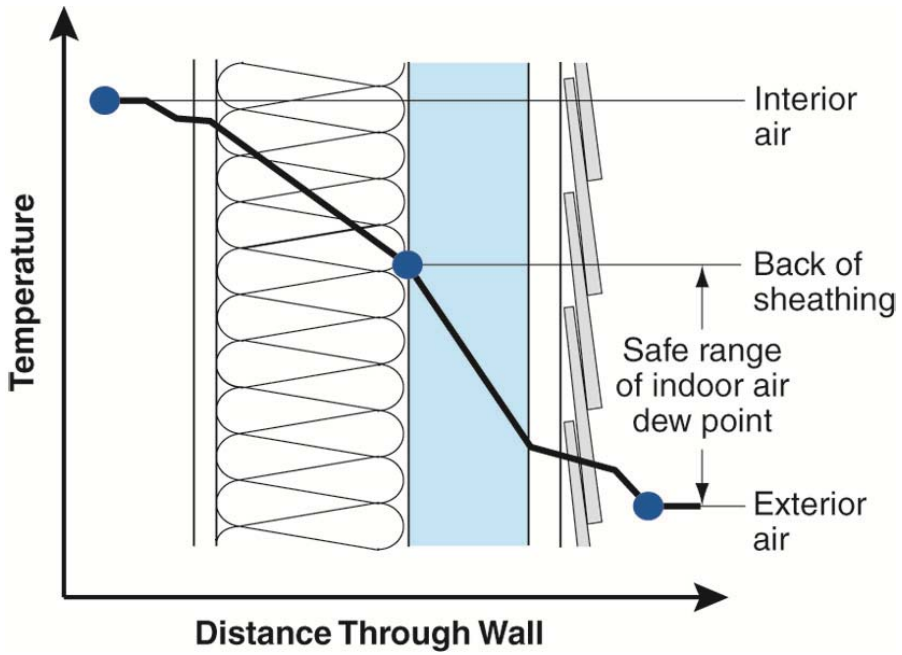


Gaps?

- Practice
  - Lots of practical experience
- Theory
  - Misconceptions
  - Missing context
- Codes & Standards
  - Playing catchup

Perceived Benefits

- Increase overall thermal performance
- Minimize thermal bridges
- Improve air tightness
- Improve rainwater management
- Eliminate potential for air leakage condensation



Perceived Problems

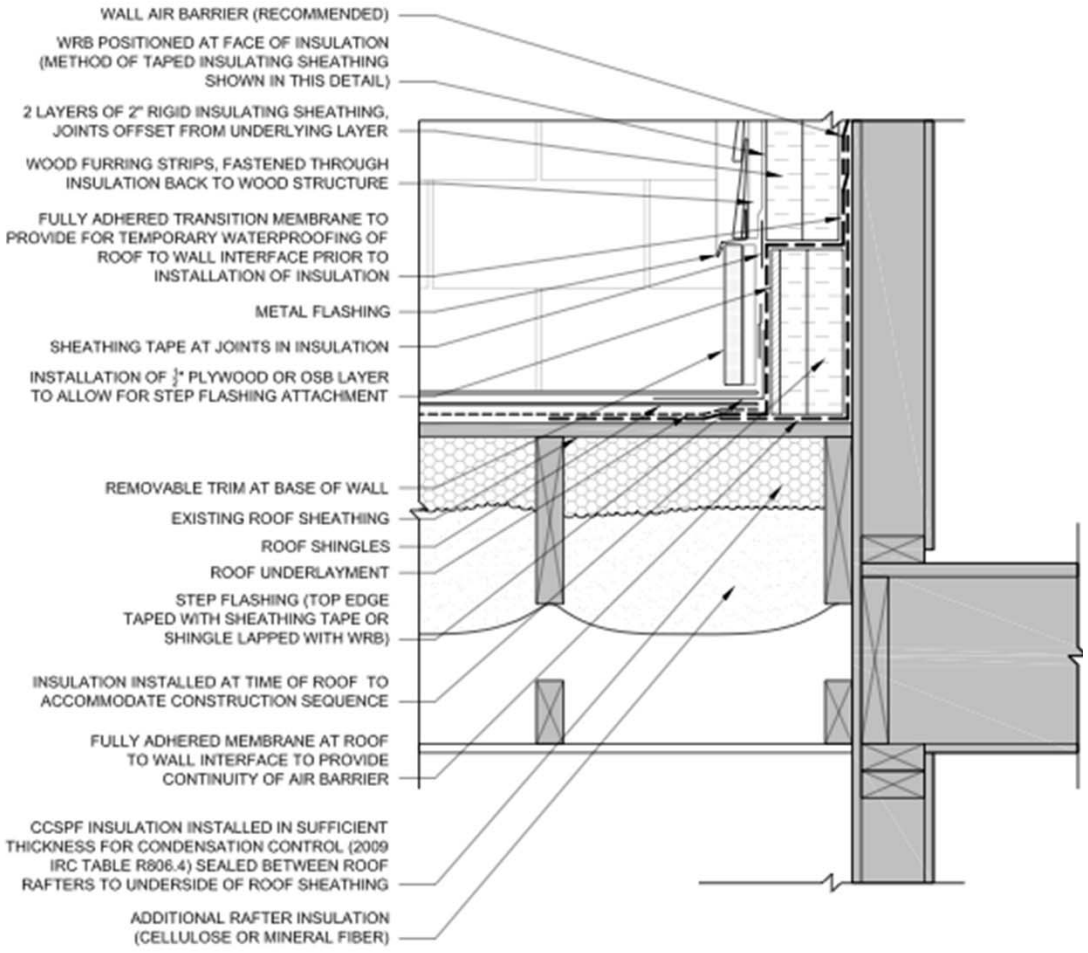
- Moisture
  - Rainwater management
  - Vapor diffusion condensation
- Structural
  - Wind load (lateral & perpendicular)
  - Gravity load
- Fire
  - Lack of code accepted assemblies

Work to Close Moisture Gaps

- BSC
- Private Industry (mfrs, builders, etc.)

Rainwater Management Details

- 62 details provide guidance on ext. insulation retrofits
  - Windows
  - Roofs
  - Balconies
  - Decks



Field Testing & Demonstration

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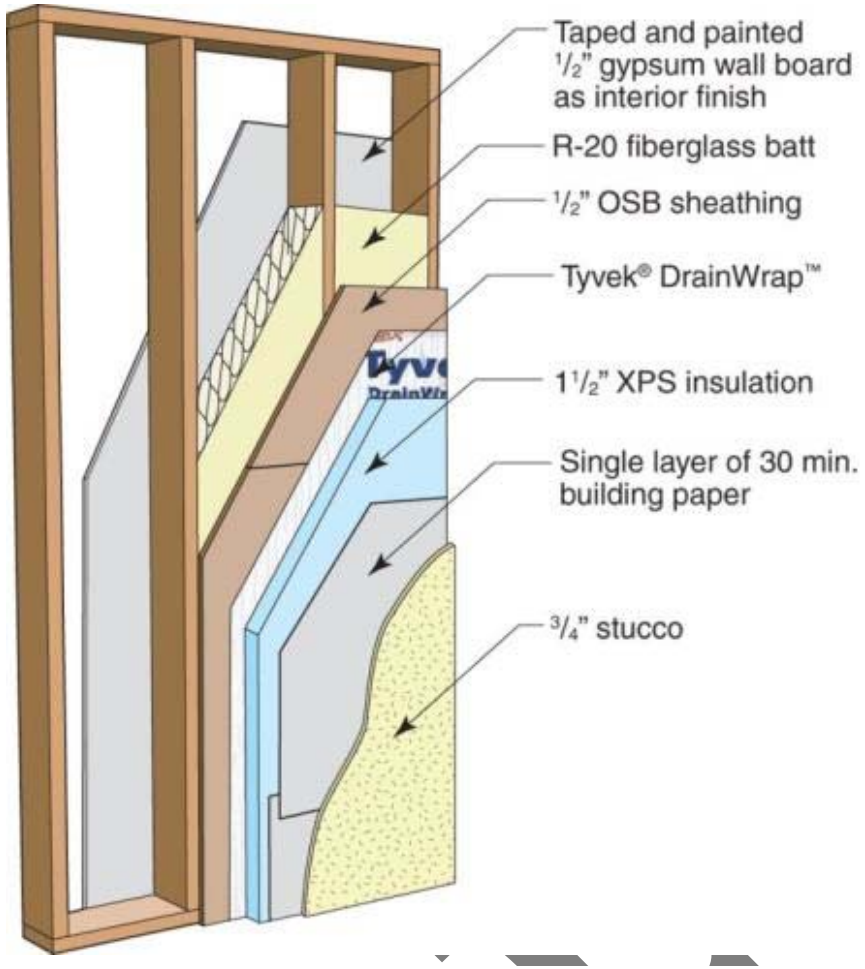


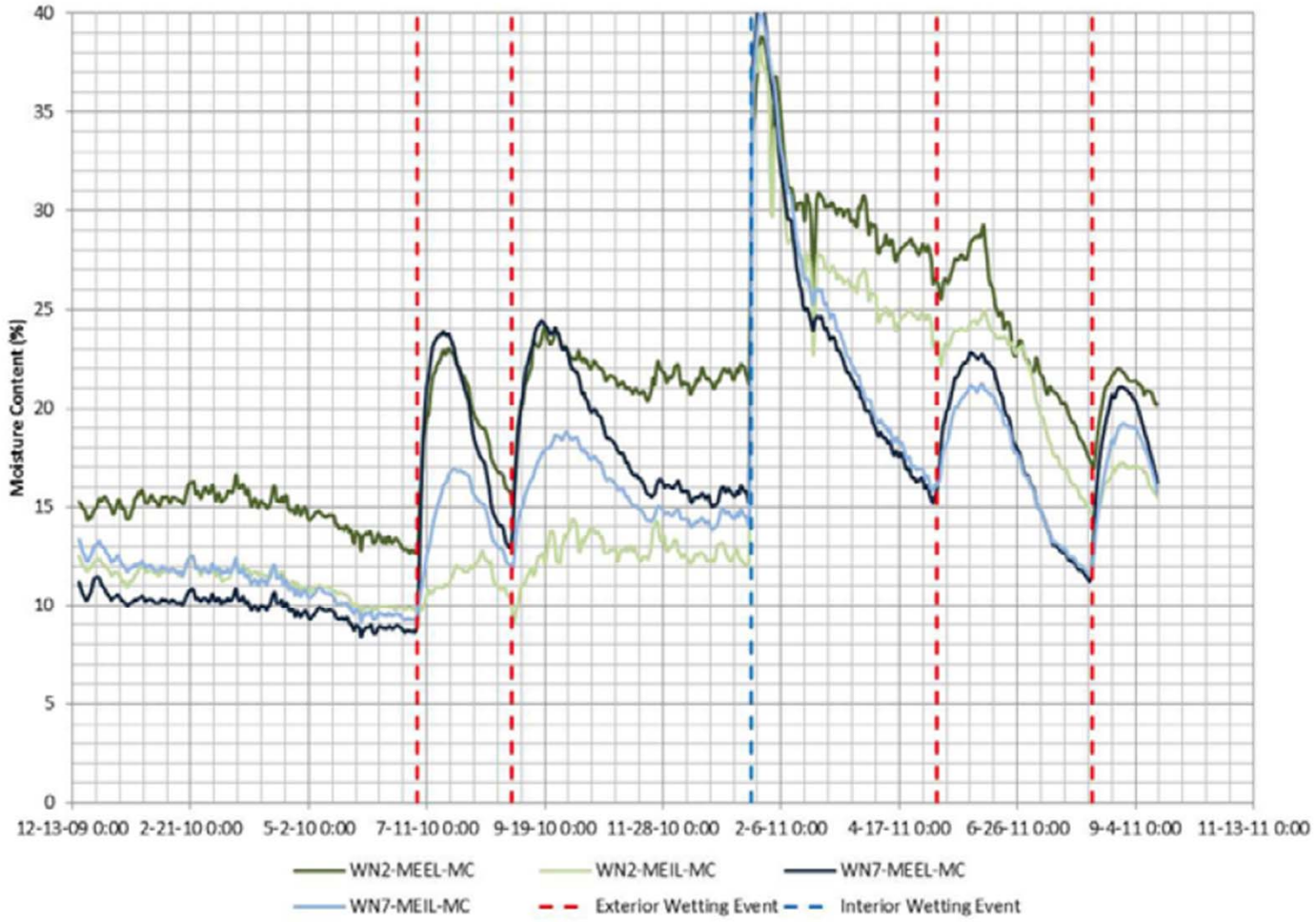
Round1: Interior Wetting & Rain

Round1: Interior Wetting & Rain

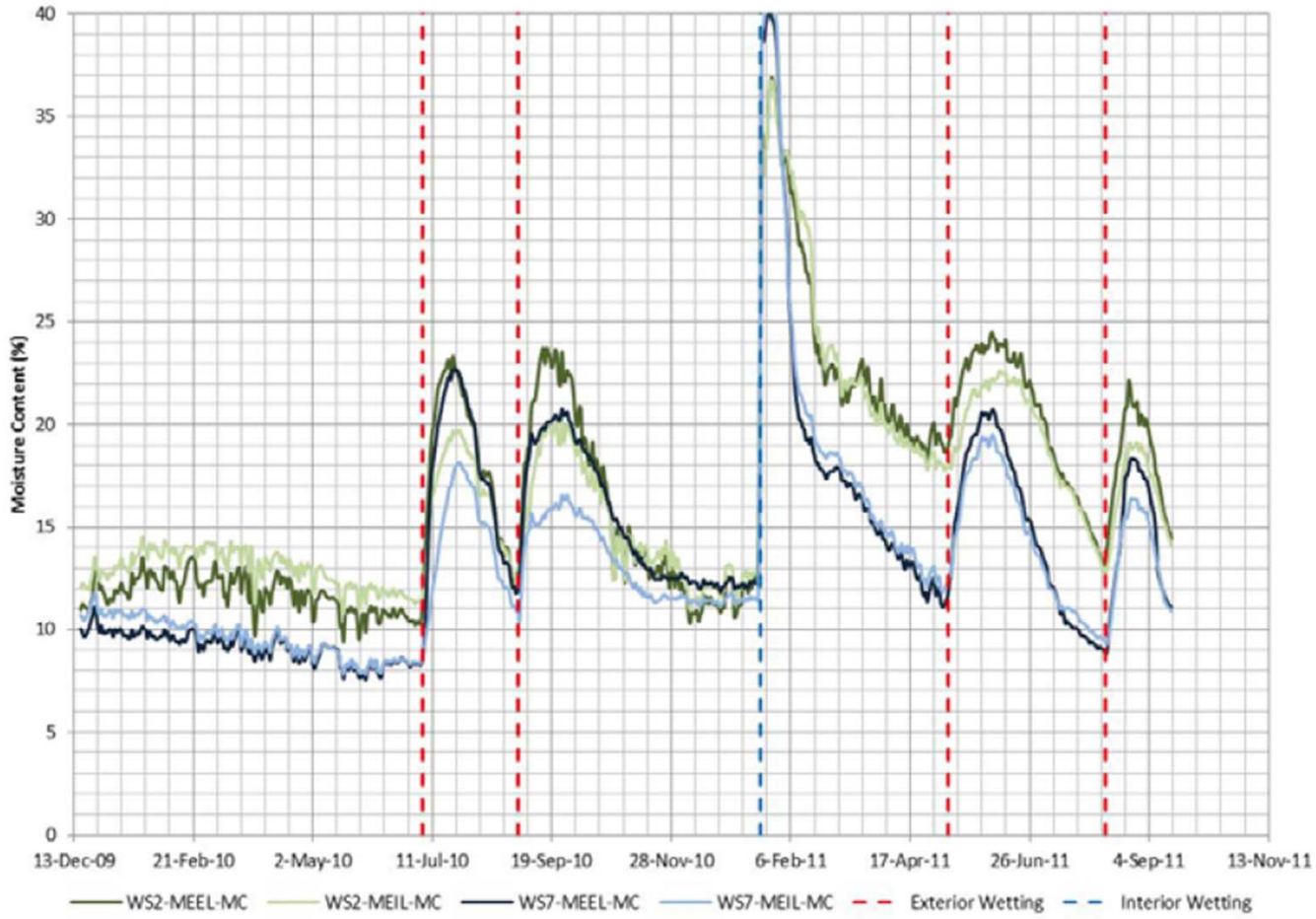
Round1: Interior Wetting & Rain

Round1: Interior Wetting & Rain (no XPS)

Round2: Exterior Wetting & Rain



Round2: Exterior Wetting & Rain



Round2: Exterior Wetting & Rain

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Round2: Exterior Wetting & Rain

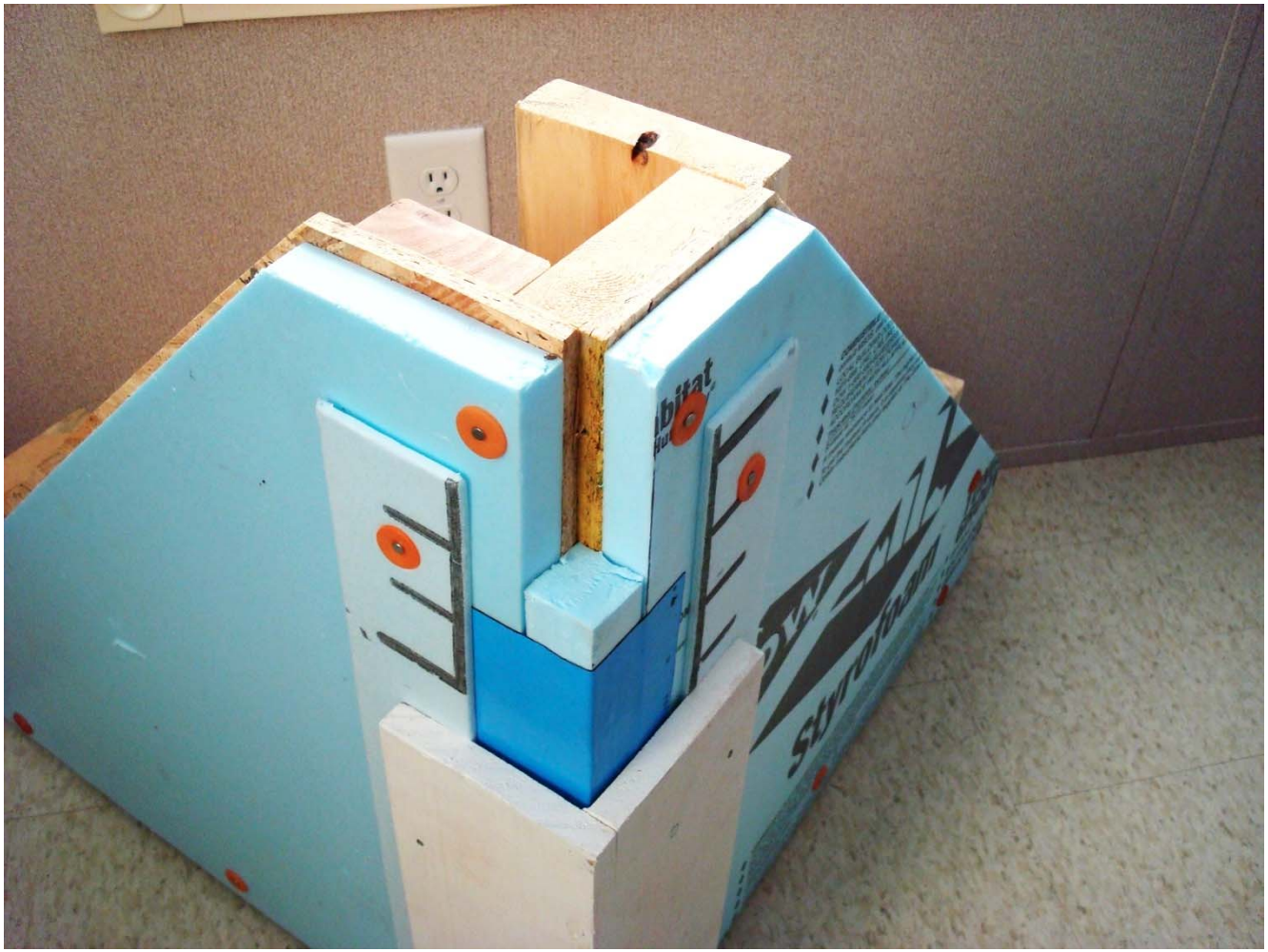
Remaining Moisture Gaps

- Hygric Redistribution:
  is this effect significant enough to be
  - Useful?
  - Problematic?

Work to Close Structural Gaps

- BSC
- FSC and NYSERDA /SFA
- NAHB
- others

Lateral Wind Loads



Lateral Wind Loads

Perpendicular Wind Loads

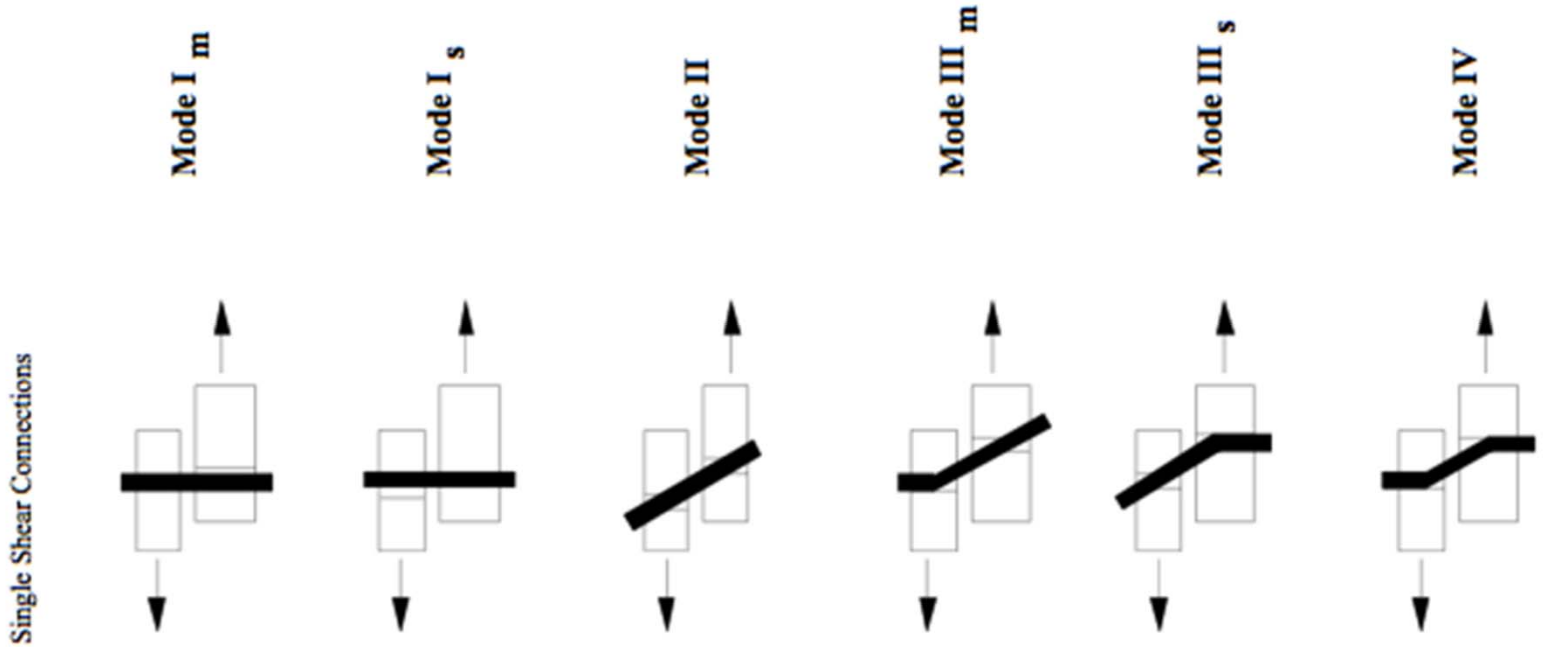
- American Wood Council 2005 NDS

Fastener Type	Unthreaded Shank Diameter (in)	Withdrawal Capacity (W) per inch of thread penetration
#8 Wood Screws	0.164	82 lbs
#10 Wood Screws	0.190	96 lbs
#12 Wood Screws	0.216	109 lbs
¼" Lag Screws	0.250	173 lbs

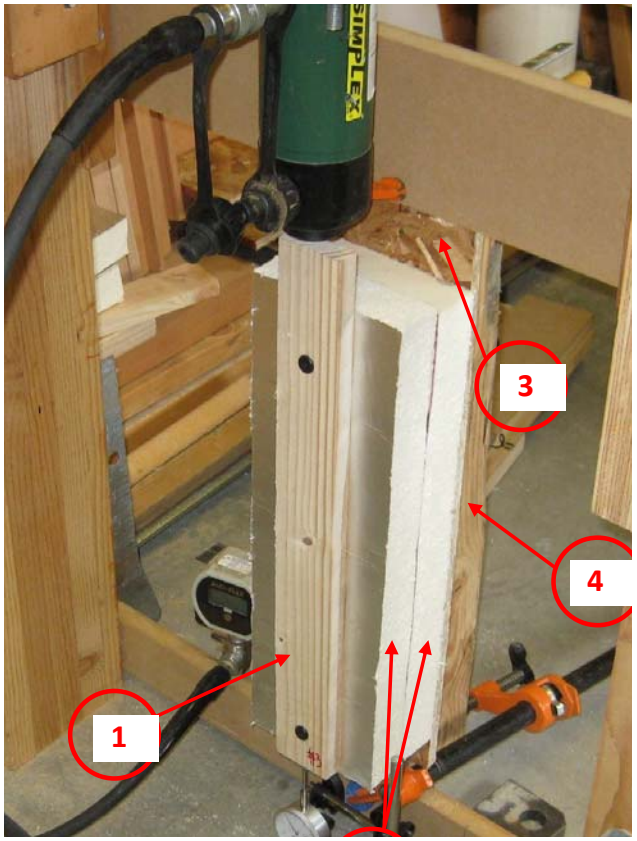
	#8 Wood Screw		#10 Wood Screw		#12 Wood Screw		1/4" Lag Screw	
	Furring Spacing (in)		**Furring Spacing (in)**		**Furring Spacing (in)**		**Furring Spacing (in)**	
Vertical Fastener Spacing	**16"**	**24"**	**16"**	**24"**	**16"**	**24"**	**16"**	**24"**
8"	148	99	172	115	195	130	301	200
12"	99	66	115	76	130	87	200	134
16"	74	49	86	57	98	65	150	100
24"	49	33	57	38	65	43	100	67

Gravity Loads (i.e. cladding loads)

- Begin with AWC TR-12
  - Dowel fastener connects 2 pcs of wood (with an empty space between them)



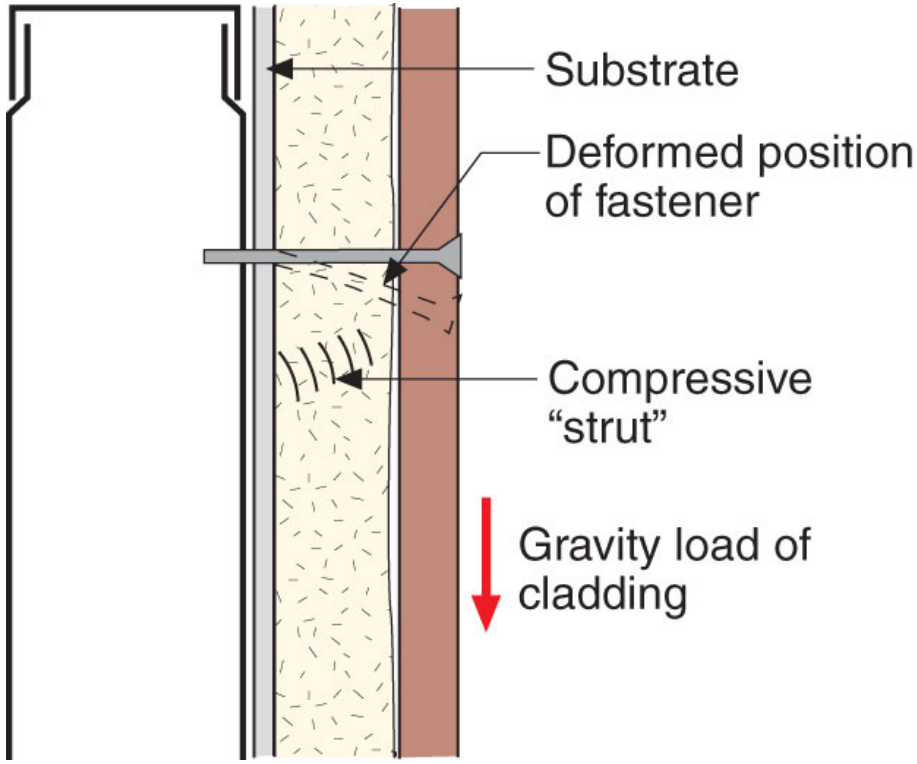
Work by others (D. Deress et. al., WJE)



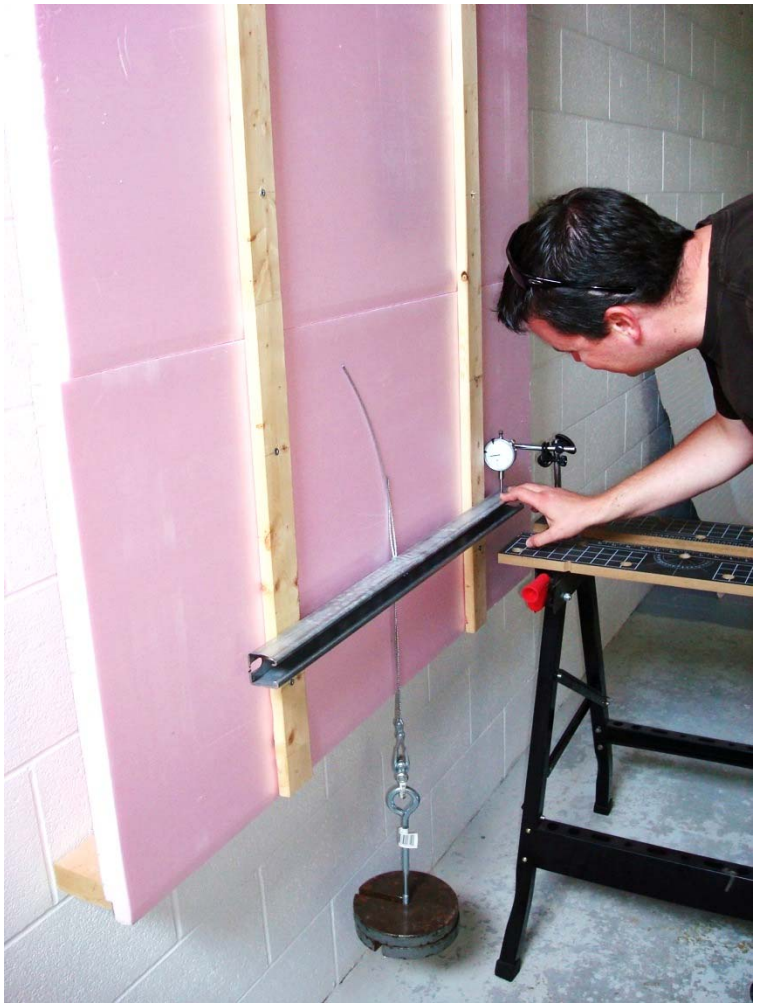
These researchers used ¼" dia. Headlok screws and loaded the system to failure (1000-2000 lb/screw !)

Gravity Loads (i.e. cladding loads)

- Strut & tie model?
  - the space between the pieces of wood isn't empty, it's filled with insulation



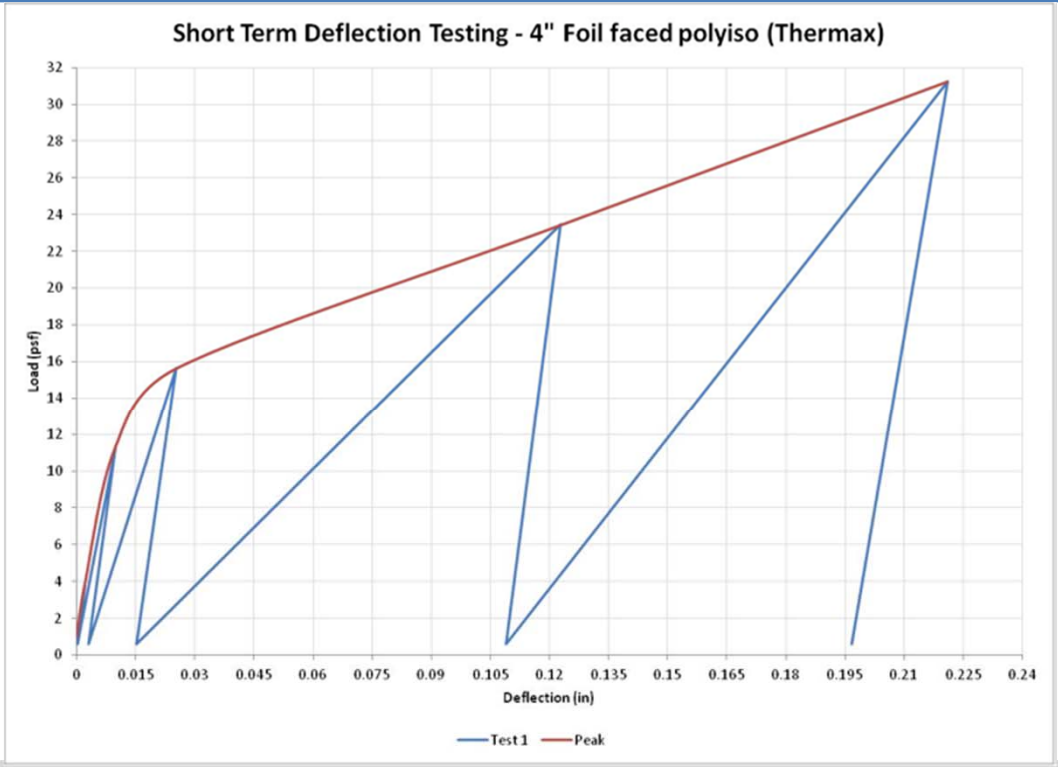
Short-term Gravity Load Response

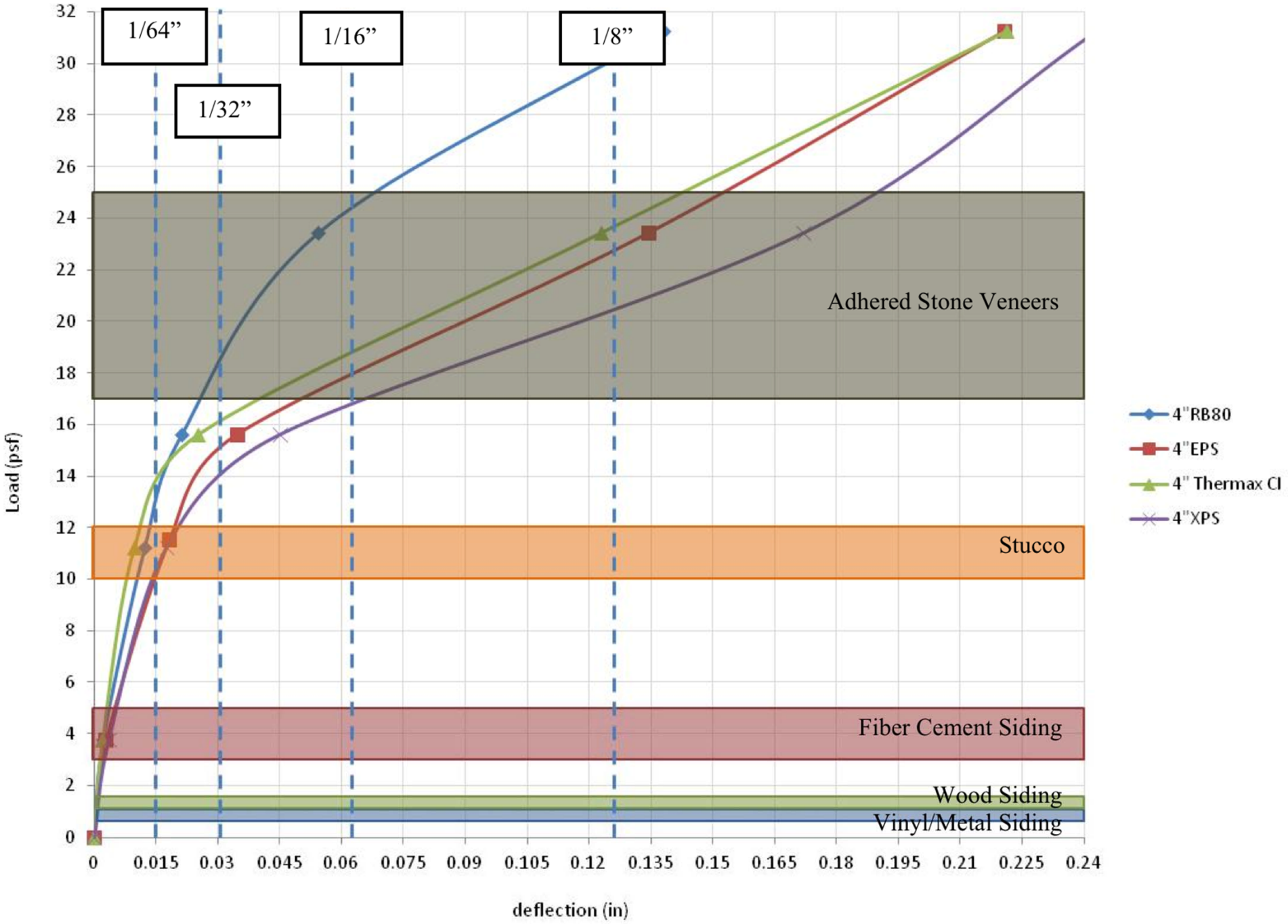


Short-term Gravity Load Response

Short-term Gravity Load Response

Total Load (lbs)		Load / ft2 (lbs)	Load/fastener (lbs)
120	Fiber Cement	3.8	8.6
370	Hard Coat Stucco	11.6	26.4
500		15.6	35.7
750	Adhered Stone	23.4	53.6
1000		31.3	71.4




1/64”
1/32”
1/16”
1/8”
Adhered Stone Veneers
Stucco
Fiber Cement Siding
Wood Siding
Vinyl/Metal Siding
4" RB80
4" EPS
4" Thermax CI
4" XPS
Load (psf)
deflection (in)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
0
0.015
0.03
0.045
0.06
0.075
0.09
0.105
0.12
0.135
0.15
0.165
0.18
0.195
0.21
0.225
0.24

Short-term Gravity Load Response

- For 4” thick insulation w/ #10 screws
  - Material type has a small impact
  - Higher compressive strength insulation = less delta

- Current consensus allow 0.015” (1/64”) deflection
- Too small relative to other movements (e.g. moisture)?

$$\Delta D = \frac{D_I(M_F - M_I)}{30(100)/S_T - 30 + M_I} \qquad (13\text{–}3)$$

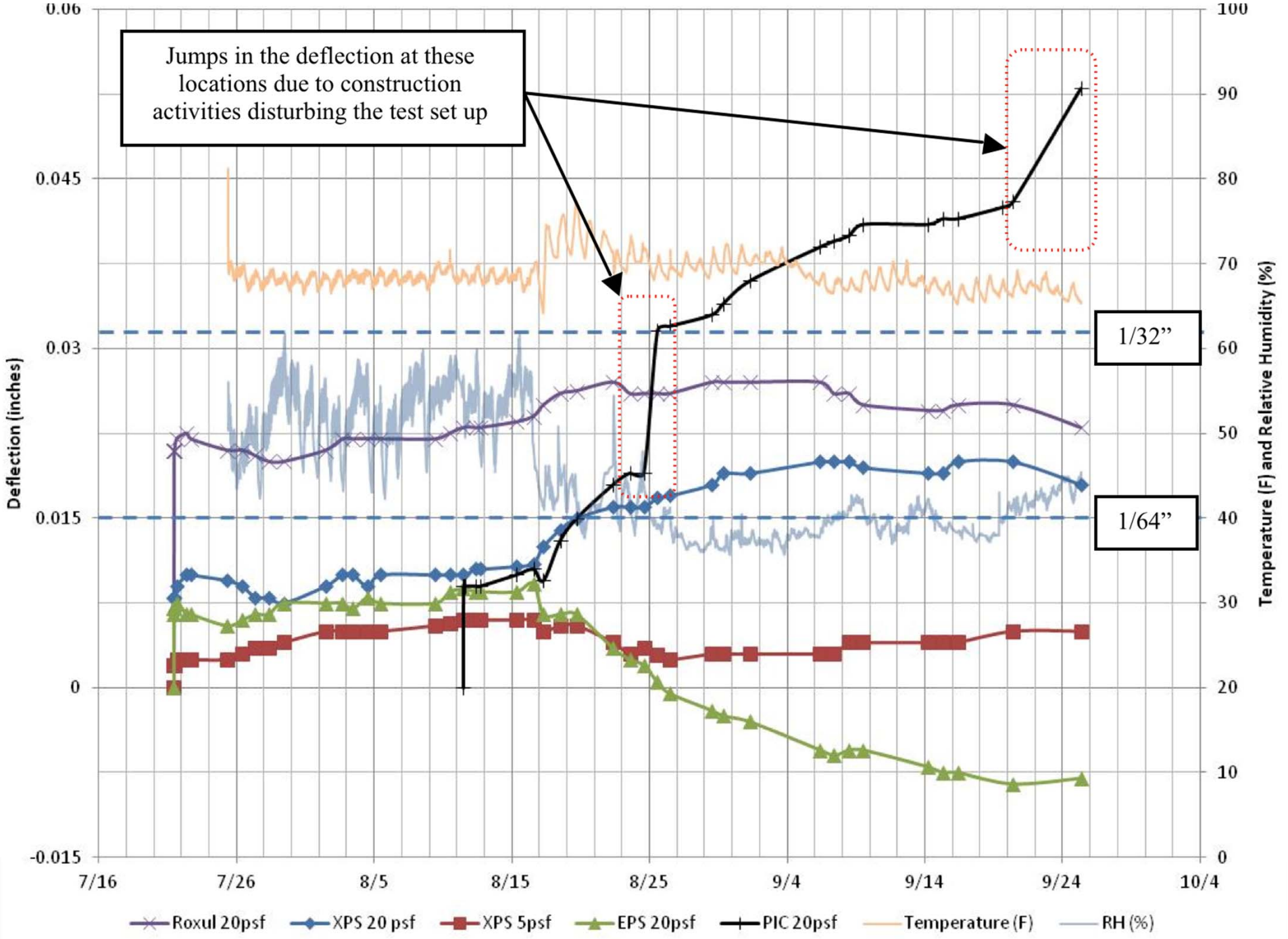
Predicted change in dimension (in/1000)							
S_T (%)	7	Starting Moisture Content (%wt)					
D_I (in)	3.5	20	18	16	14	12	10
Ending MC (%wt)	20	0	17	34	51	68	86
	18	-17	0	17	34	51	69
	16	-33	-17	0	17	34	51
	14	-50	-34	-17	0	17	34
	12	-67	-50	-34	-17	0	17
	10	-84	-67	-51	-34	-17	0
	8	-100	-84	-68	-51	-34	-17
	6	-117	-101	-84	-68	-51	-34

Short-term Gravity Load Response

- System capacities for 0.015” (1/64”) deflection
  - EPS & XPS ~ 10 psf or 23 lb/fastener
  - Polyiso & MF ~ 13 psf or 29 lb/fastener

- Comparison to NYSERDA work
  - 5% yield from TR-12 w/ #10 screws & 4” space – 27 lb

Long-term Gravity Load Response


Jumps in the deflection at these locations due to construction activities disturbing the test set up
1/32”
1/64”
Deflection (inches)
Temperature (F) and Relative Humidity (%)
0.06
0.045
0.03
0.015
0
-0.015
100
90
80
70
60
50
40
30
20
10
0
7/16
7/26
8/5
8/15
8/25
9/4
9/14
9/24
10/4
Roxul 20psf
XPS 20 psf
XPS 5psf
EPS 20psf
PIC 20psf
Temperature (F)
RH (%)

Long-term Gravity Load Response

- Long term deflections
  - Extremely small (close to experimental error)
    - Can barely see creep under low (5 psf) load
    - Very little movement under high (20 psf) load
  - Influenced by lab temperature & humidity conditions?

- What initial deflection is acceptable?
- What long term deflection is acceptable?
- These must be considered separately

Remaining Structural Gaps

- Compare wider range of system tests to calcs
  - 5% TR-12
- What deflections are allowable?
  - Initial
  - Long-term
- Changing environmental conditions
  - e.g. moisture, temperature, etc.
  - How do these impact gravity load deflections?
  - Deflections vs other dimension changes?

Work to Close Fire Gaps

- Private Industry (mfrs)
  - e.g. Dow Thermax CI

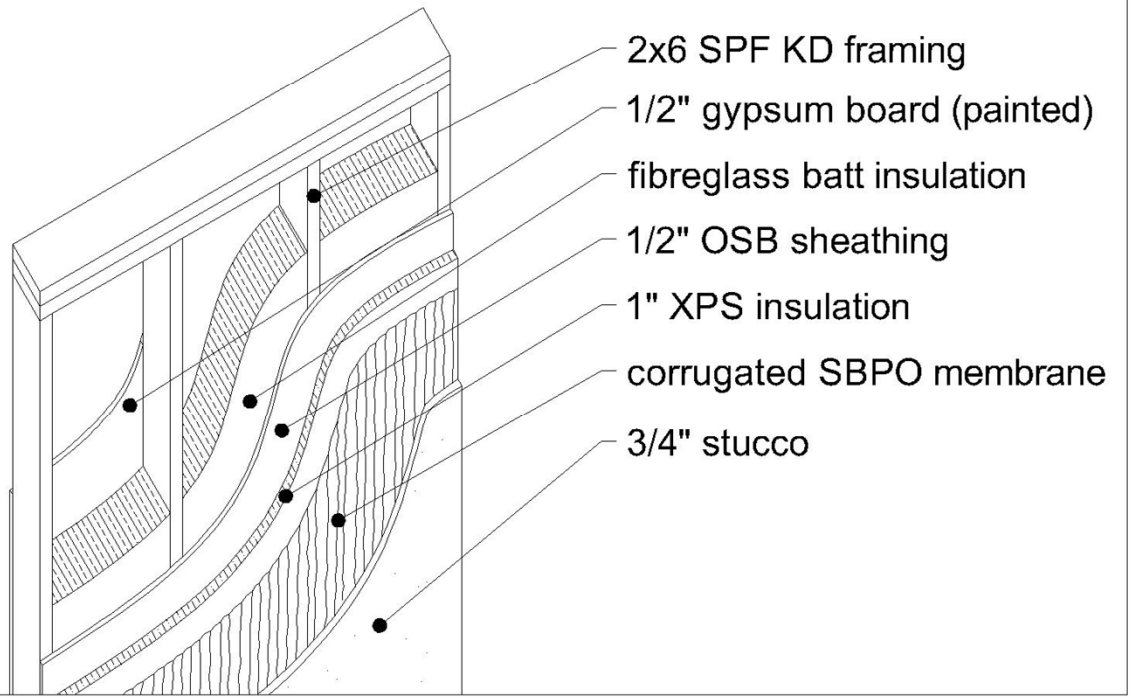
- Little work ahs been done to close this gap
  - Not necessarily a performance problem rather a regulatory problem
  - Change in any element in an assembly requires a new test
  - $20-50k / test

Exterior Insulation & Cladding Retrofits

Thank You

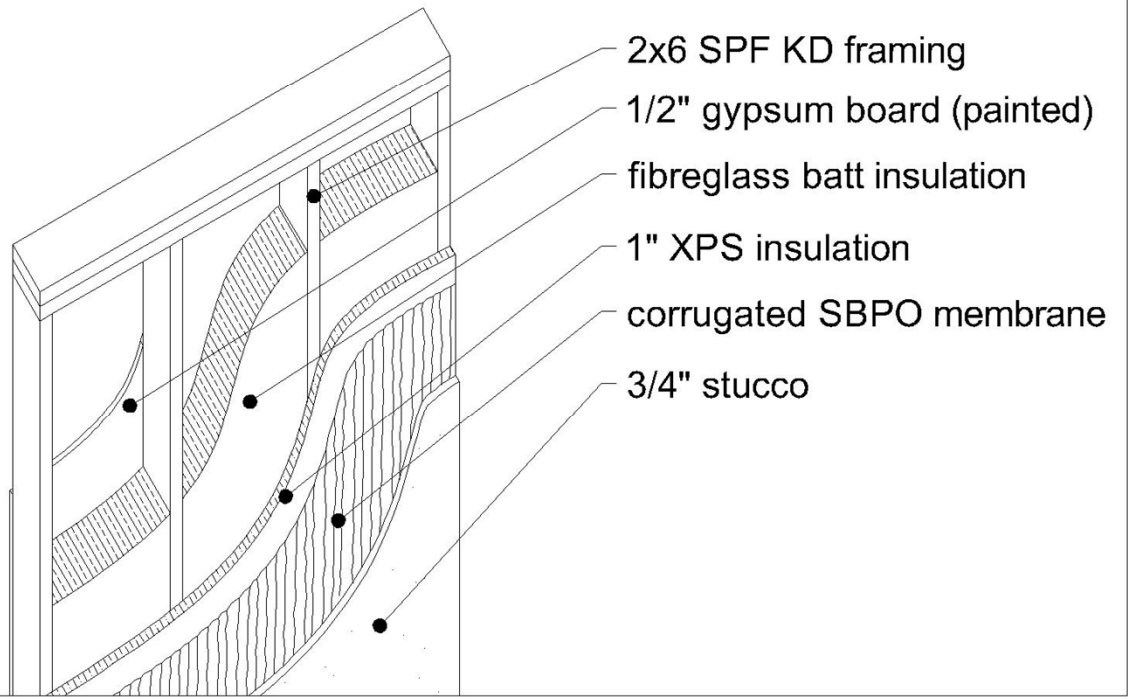
Test Hut Ext. Insul. w/ OSB

Panel 7: Exterior Insulation 2X6
(no poly/insulated sheathing)



Test Hut Ext. Insul. w/o OSB

Panel 10: Exterior Insulation 2X6
(no poly / no OSB / insulated sheathing)



Test Hut Ext. Insul. w/o OSB

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